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THE BACTERIAL DISEASES OF PLANTS: A CRITICAL REVIEW OF THE PRESENT STATE OF OUR KNOWLEDGE.

By Erwin F. Smith.

(*Continued from Vol. XXX, p. 924.*)

V.

II. THE HYACINTH (HYACINTHUS ORIENTALIS L.).

2. THE BACTERIOSIS OF HYACINTHS (1889).

(I) The disease:

(1) *Author, Title of Paper, Place of Publication, etc.*—This disease was described by Dr. A. Heinz, Director of the Botanical-Physiological Institut in Agram. His paper (35) Zur Kentniss der Rotzkrankheiten der Pflanzen was published in *Centralblatt f. Bakt. u. Parasitenkunde*, Bd. V, No. 16, 12 April, 1889, pp. 535–539.

(2) *Geographical Distribution.*—The disease was discovered in some potted hyacinths received from a florist in Agram. There is no statement respecting its occurrence in the field or in hothouses.

(3) *Symptoms.*—All of the potted plants developed equally well until blossoming time, the last of January. Then visible differences appeared, although the plants were exposed to the same external conditions. Some of the plants continued their normal development, unfolded their blossoms in regular order, and remained entirely sound. Others were delayed in their development, and several circumstances indicated the presence of a disease before there were unmistakable symptoms. These symptoms soon appeared. The tips of the leaves yellowed, shriveled, and dried out for a distance of some centimeters. The blossoms either fell off before unfolding or opened in irregular order, and fell off soon after. Finally, in all the diseased specimens a progressive rotting was detected. This first attacked the axes of inflorescence, and then the leaves and bulb

scales. This rot produced a viscous (schmierigem), bad smelling slime. After two or three days the bulbs were entirely softened, and only the slightest pull was necessary to draw the leaves and scapes out of the bulb scales.

(4) *Pathological Histology.*—A microscopic examination of the slime and of the affected tissues showed the existence of great numbers of bacteria. Primarily, they occupied the intercellular spaces; but the dead cells and the vessels were also full of them. The nucleus of the cell resisted longest, and could still be detected after the rest of the protoplasm was destroyed. No Hypomyces or other fungus was present.

(5) *Direct Infection Experiments.*—No record of any.

(II) THE ORGANISM.—*Bacillus hyacinthi septicus* Heinz.

This name does not mean that Dr. Heinz regarded his organism as in any sense a variety of *B. hyacinthi* Wakker, the practice of using trinomials to designate varieties not being current in bacteriology or generally accepted as good usage in any branch of botany. Dr. Heinz simply followed a common and vicious practice in the selection of his specific name, the literature of bacteriology being full of trinomials, quadrinomials, and even more extended names. Of course, all of these polynomials, Dr. Heinz's included, must give way to binomial names, but in as much as I have not seen his organism, and as it was not fully described, I prefer to leave the consideration of its proper nomenclature to whomsoever shall have occasion to study it thoroughly.

1. *Pathogenesis:*
   (A) Yes.
   (B) Yes. Very easy. "The material may be taken from any suitable diseased spot; and it is demonstrable that everywhere the same species of bacterium is present in large quantities—I might almost say in pure culture—foreign organisms occurring only in the outer bulb scales, where they might be expected, and where they are of no consequence." "The here observed bacteria belong to a single species." "I could not discover a mixture of different bacteria; the above named is also unlike *Bacterium termo* (Cohn?). So much is

established not only by the microscopic investigation but also by the very successful culture experiments. *Bacillus butyricus* was also not to be found."

"Necessary precautions being taken for granted, a pure culture is obtained the easiest, when, by means of flamed instruments, the epidermis is lifted from a diseased but not yet entirely softened spot, a trace of the slime removed from the parenchyma, and the same transferred to a nutrient substratum. The material may be taken just as well from a bulb scale, only in this case one must set to work so much the more carefully. Whether we inoculate a liquefied substratum directly, or put a trace of the slime in sterile water, and inoculate only from this (a very simple method of dilution, which here leads to entirely satisfactory results), we always get on the plate an abundance of the uniform colonies of this bacterium."

(C) Yes. The inoculation experiments were very successful. "If, by means of a needle, an extremely small quantity of the bacilli are pricked into the epidermis of a leaf, or of a scape of an otherwise entirely sound hyacinth, the sickening of this part with the described symptoms can usually be observed within 24 hours. The most destructive action takes place around the point of inoculation, over a breadth of about 3 cm. Here at first the tissues softens, the part becoming transparent. Finally, as a rule, the organ breaks, as its tissue, including the epidermis, is changed for the specified distance into the characteristic, slimy-viscous, rotten-smelling pulp. We obtain the same result when the inoculation is made on a bulb scale. The inoculated scale first sickens, but soon after the neighboring ones also become affected, and the disease spreads from this point even into the parts above ground. The reverse behavior (inoculation of the aerial parts, and the spread of the disease into the bulb) could not be observed. This circumstance indicates, in all probability, that under natural conditions the disease spreads from the bulb upward. I would add, that the spread of the bacilli from the point of inoculation is very rapid. If a leaf 15 to 20 cm. long is inoculated at its base outside of the bulb, the bacilli may be detected even after 24 hours, at a distance of 5 to 10 cm. in the leaf parenchyma."

(D) Apparently; in part, at least. Statements not very explicit.

Conclusion.—Pathogenic nature clearly established.

Note.—Lack of full proof under D seems to be atoned for by repetitions under B and C.

2. *Morphology:*

(1) *Shape, size, etc.*—The organism is a conspicuous bacillus, with rounded ends. It is 4 to 6 x 1μ, and always single. Shorter rods occur; but direct observation shows these to be younger stages, which have resulted from division. The process of division is easily observed in hanging drops.

(2) *Capsule.*—No mention of any capsule.

(3) *Flagella.*—Organism actively motile. Nothing concerning organs of motion.

(4) *Spores.*—No mention of any spores.

(5) *Zooglœa.*—"Inoculated nutrient fluids become uniformly cloudy. I have not observed in them any local heaping-up of the bacilli."

(6) *Involution Forms.*—No mention of any involution forms.

3. *Biology:*

(1) *Stains.*—No special peculiarities. The organism colors readily with all the ordinary stains.

(2) *Gelatin.*—Organism grows well upon ordinary gelatin. The surface colonies on plate cultures are circular, about 2 mm. in diameter, smooth and shining, not very prominent, bluish-white with a somewhat darker center, translucent. The buried colonies have an oval form, and are rather (ziemlich) pointed at the poles. They are yellowish-white and dull. The bacillus does not liquefy gelatin.

(3) *Agar.*—Growth as on gelatin. There are no noteworthy differences either in plate or stab cultures. In stab cultures the bacillus grows uniformly the whole length of the stab, and

forms on the surface of the agar a smooth, bluish-white, intensely shining growth, which does not reach the wall of the tube even after weeks. After 8 to 10 days little vesciculate projections appeared along the stab.

(4) *Potato, etc.*—Organism grows well upon potato, forming after 36 hours a dirty yellow, slimy covering, the surface of which is granular. Cultures several days old sent forth an intense rotten odor.

(5) *Animal Fluids.*—No mention of specific sorts. See (II) 2 (5).

(6) *Vegetable Juices.*—No mention of any trials.

(7) *Salt Solutions and other Synthetic Media.*—The organism grows well in Cohn's nutrient solution, and in sugar solutions, etc. In sugar solutions, with addition of sodium phosphate and peptone, a fine growth, but no butyric acid.

(8) *Relation to Free Oxygen.*—Aerobic. No special experiments, but from the behavior of the agar stab cultures the bacillus is probably also facultative anaerobic.

(9) *Reducing and Oxidizing Power.*—No statement.

(10) *Fermentation Products, and other Results of Growth:*

(a) *Gas Production.*—No statement.

(b) *Formation of Acids.*—No odor of butyric acid could be detected in any of the cultures. No mention of any other acid.

(c) *Production of Alkali.*—No statement.

(d) *Formation of Pigment.*—Organism dirty yellow on potato.

(e) *Development of Odors.*—Causes a rotten smell in the host plants, and an intensely putrid odor on potato. Chemical nature of the odor not determined. No smell of butyric acid.

(f) *Enzymes.*—No statement. Cell walls are softened and destroyed, and protoplasm is consumed in the presence of this organism.

(g) *Other Products.*—No mention of any.

(11) *Effect of Dessication.*—No statement.

(12) *Thermal Relations:*

(a) *Maximum for Growth.*—Not determined.

(b) *Optimum for Growth.*—Not determined.

(c) *Minimum for Growth.*—Not determined.

(d) *Death Point.*—Not determined.

(13) *Relation to Light.*—No statement.

(14) *Vitality on Various Media.*—No statement.

(15) *Effect on Growth of Reaction of Media* (*acid, neutral, alkaline*).—No statement.

(16) *Sensitiveness to Antiseptics and Germicides.*—No statement.

(17) *Other Host Plants.*—The common onion, *Allium cepa*, was inoculated both in the leaves and in the bulbs, and in both cases with positive results. This plant must therefore be included as a possible host. Inoculations into other plants, such as Richardia, Chlorophytum, Triticum, Phaseolus, etc., gave negative results.

(18) *Effect upon Animals.*—No statement, and probably no experiments.

(III) ECONOMIC ASPECTS:

(1) *Losses.*—Disease not observed in the field.

(2) *Natural Methods of Infection.*—Not known.

(3) *Conditions Favoring the Spread of the Disease.*—Not known.

(4) *Methods of Prevention.*—No suggestions.

Remarks.—Organism not satisfactorily described. The first part of the paper is devoted to a brief review of papers by Wakker and Sorauer. De Toni and Trevisan in (11) Saccardo's *Sylloge*, vol. VIII, p. 984, under *B. hyacinthi* Wakker, make the following remark concerning *B. hyacinthi septicus* Heinz,—"verisimiliter huc spectat." The reason for this remark is not apparent. Certainly, so far as we can judge from the published statements of Drs. W. and H., the two organisms are widely different in their pathogenic effects, and also in their behavior on culture media. The rapid destruction of the host by Dr. Heinz's germ is specially noteworthy.

Whether the hyacinth disease described by Dr. Sorauer is distinct or identical with the preceeding, whether it is identical with the white rot of the Netherlands, or, finally, whether it is in any proper sense of the term a bacterial disease at all, must be left an open question. His account of the symptoms especially in the foliage certainly suggests the disease described by Heinz. Sorauer himself identifies it with the white rot of the hyacinth described by Schneevoogt and others, and also erroneously supposes it to be the same as the yellow disease described by Wakker. Dr. Sorauer made numerous and apparently quite careful microscopic examinations, but no pure cultures. His attemps at direct infections yielded negative results and he says that the bacteria do not attack sound well ripened bulbs under normal meteorological conditions. The fungus, *Hypomyces hyacinthi* Sorauer, was closely associated with this rot but is believed to be only a secondary trouble in as much as the bacteria were sometimes found in the affected tissues where no mycelium could be detected. The fungus may however spread the disease by acting as a carrier of the microorganisms. The latter consisted of coccus forms and rods, and were identified, in part, as *Clostridium butyricum* (*Bacillus amylobacter*), apparently on no better grounds than the microscopic appearances and a bad smell supposed to be due to butyric acid. This work was done fifteen years ago and now has little other than a historic value. The following are Dr. Sorauer's papers:

(**36**) Der weisse Rotz der Hyacinthenzwiebeln, *Deutscher Garten*, 1881, pp. 193, (not seen), and (**37**) Der weisse Rotz (Bacteriosis) der Hyacinthenzwiebeln, Sorauer, *Handbuch der Pflanzenkrankheiten*, 2nd. ed., part II, pp. 95–102, with one plate (devoted exclusively to the Hypomyces), Berlin, 1886.

Concerning the "white rot" of the Netherlands, Wakker states distinctly that it is not a parasitic disease, and seems to have proved that it does not attack sound bulbs but only such as have been weakened by a nonparasitic gummosis. Whether this is always the case may, perhaps, be regarded as doubtful, in as much as Dr. Wakker's inoculation experiments were not very numerous. This white rot is a slimy, and often foamy, stinking, bacterial decay to which gummosed bulbs are frequently subject in rainy, warm weather, particularly after the bulbs are dug and placed in silos in the earth to undergo a ripening process. The disease may also appear afterwards in rooms where the bulbs are spread out to dry. The whole or only a part of a bulb may be attacked according as the whole or only a part is gummy. The diseased parts are soft and white and look as if boiled. Dr. Wakker's views may be found in (**34**) and in (**38**) Contributions à la pathologie végétale. VI. Nouvelles recherches sur la gommose des Jacinthes et plantes analogues. *Archives néerlandaises*, T. XXIII, Haarlem, 1889, pp. 383–396, 2 plates.

In confirmation of the statements made in No. 1 of this series, p. 632, 2nd paragragh, and as a curious commentary on the way in which many books are thrown together, we may in passing refer to the account of "the white or yellow rot of hyacinth bulbs" given in Dr. Frank's new book (**39**) *Die Krankheiten der Pflanzen*, Bd. II, pp. 23–25, Breslau, 1896. Most of the two pages is wasted in an exposition and criticism of Dr. Sorauer's views; Wakker's studies are condensed into four lines and badly at that; no mention is made of Heinz's paper; and the review concludes as follows: "Für eine pathogene Bakterienwirkung fehlt wenigstens bis jetzt der Beweiss."

EDITOR'S TABLE.

We publish in our news department an account of a project now on foot in Europe for the protection of the large game of Africa. It is greatly to be hoped that this plan will be carried into effect without delay. Certain members of the French Société d'Acclimatation have formed a committee having for its object the domestication of the African elephant, which seems to be entirely feasible. Meanwhile, in America the plans for the preservation of a herd of bison are not being realized. This is due to the neglect of Congress to legislate for the proper protection of game in the Yellowstone National Park. This must be done at an early day, or the herd of bison there will be exterminated. It is expected that a portion of Fairmount Park, Philadelphia will be set apart for the breeding of bison. If this hope shall be realized and other small herds now existing are preserved, this species may be saved from extinction as a result of inbreeding. This fate is said to be overtaking the herd of Aurochsen or European bison in the government preserve in Lithuania. They are said to be becoming very infertile. The seals of Alaska are having a rest, and their destruction is for the time being delayed. Enough remain to enable them to recover their old abundance if protected. The American and British Commissions are composed of able men who will see